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(54) **Adhered surface coverings.**

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(73) Proprietor: Armstrong World Industries, Inc.
P.O. Box 3001 Liberty and Charlotte Streets
Lancaster Pennsylvania 17604 (US)

(72) Inventor: Eckert, Donald Charles
750 West Vine Street
Lancaster, PA 17603 (US)
Inventor: Lilley, George Lawrence
R.D. 3
Manheim, PA 17545 (US)
Inventor: Tshudy, James Arthur
Box 224, R.D. 4
Ephrata, PA 17522 (US)
Inventor: George, Jay Richard
R.D. 6
Manheim, PA 17545 (US)
Inventor: Sensenig, Darryl Lamar
364 Hershey Mill Road
Mountville, PA 17554 (US)

(74) Representative: Darby, David Thomas et al
Abel & Imray Northumberland House 303-306
High Holborn
London WC1V 7LH (GB)

Courier Press, Leamington Spa, England.

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Description

The present invention relates to adh red surface coverings, and more particularly to adhered surface coverings which will be suitable for use over stable or unstable subsurfaces.

Surface coverings for walls, floors, ceilings and the like have traditionally been adhered to subsurfaces such that the surface coverings are fixed and immobile. Adhesion is required for ceilings and walls because of gravitational effects, but floor coverings are held to a subfloor by gravity and, thus, the use of an adhesive is not always necessary. The criteria under which a floor covering may be loose-laid are discussed in EP—A—83220, published on July 6, 1983, the contents of which are incorporated herein by reference. This application is referred to herein as the "Patent Application".

U.S. Patent No. 4,233,793 describes a method of bonding individual wooden floor members to a subfloor using an elastomeric cushioning adhesive of sufficient strength to overcome normal horizontal and vertical expansive buckling forces resulting from changes in the moisture content of the wooden floor members with atmospheric humidity changes. This patent is concerned with the problems occurring at the boundaries between the individual members as a result of their own shape change; it is not concerned with and provides no solution to the problems caused by dimensional changes in subsurfaces.

The present application relates to processes for adhering surface coverings to subsurfaces using an adhesive whereby subsurface movement will not cause the adhesive bond to fail.

Accordingly, one objective of the present invention is to provide a method by which a surface covering may be selected, and a suitable adhesive may be selected for use with the surface covering. The selection of the adhesive will depend on the dimensional stability of the subsurface and the performance characteristics of the surface covering.

Another objective of the present invention is to provide methods by which products comprising one or more reinforcing layers may be modified *in situ* to provide buckling characteristics which allow the products to be used as adhered surface coverings in combination with appropriate adhesives.

These and other advantages of the present invention will become apparent from the detailed description of the preferred embodiments which follow.

Figs. 1A and 1B illustrate a diagram of a computer program which may be used to calculate the bending stiffness and/or relaxed compressive stiffness values according to the present invention.

Fig. 2 illustrates an example of a continuous modification pattern as used in the examples.

Figs. 3A and 3B illustrate a diagram of a modified computer program, comparable to Figs. 1A and 1B, which may be used to calculate the adhered basis weight and/or strain according to the present invention.

The present invention concerns surface coverings which are adhered to subsurfaces using an adhesive. A process is provided whereby an adhesive can be selected for use with an unmodified surface covering such that subsurface movement will not cause adhesive failure. Processes are also provided whereby modified surface coverings may be adhered using a similarly selected adhesive, or whereby adhesives may be selected and the surface coverings modified such that the adhesives will not fail due to subsurface movement.

In one embodiment, the present invention comprises a process for adhering a surface covering to a subsurface having an ascertainable subsurface dimensional change such that said surface covering will accommodate subsurface movement without buckling, said process comprising the steps of (a) selecting a surface covering, the critical buckle strain of the selected covering being less than the subsurface dimensional change; (b) selecting a target critical buckle strain which is greater than the subsurface dimensional change; (c) measuring the relaxed compressive stiffness, the bending stiffness, and the basis weight of said selected covering; (d) calculating the adhered basis weight for a surface covering having the measured bending stiffness, the measured relaxed compressive stiffness, and a critical buckle strain which is equal to the target critical buckle strain; (e) calculating the minimum adhesive strength which will be necessary to adhere said surface covering to said subsurface in a manner which will prevent buckling; (f) selecting a suitable adhesive, and (g) adhering said surface covering to said subsurface.

In a second embodiment, the present invention comprises a process for modifying a surface covering comprising at least one reinforcing layer whereby it can be adhered without buckling to a subsurface having an ascertainable subsurface dimensional change, said process comprising the steps of (a) selecting a surface covering comprising at least one reinforcing layer, the critical buckle strain of said selected covering being less than the subsurface dimensional change; (b) selecting an adhesive having a determined adhesive strength; (c) measuring the basis weight, the bending stiffness and the relaxed compressive stiffness of said selected covering; (d) selecting a target critical buckle strain which is greater than the subfloor dimensional change; (e) calculating the adhered basis weight which would be obtained if said selected covering were adher d to said subsurface using said adhesive; (f) calculating the relaxed compressive stiffness for a modified surface covering having the measured bending stiffness, the calculated adhered basis weight, and a critical buckle strain which is equal to the target critical buckle strain, and (g) modifying said covering *in situ* such that it has a r laxed compressive stiffness which is not greater than the calculated relaxed compressive stiffness value, whereby when the modified surface covering is adhered to said subsurface using said adhesive, it will accommodate subsurface movement without buckling. This embodiment also comprises a process for the manufacture of a composite structure

by adhering the modified surface covering to the sub-surface using said adhesive, and the resulting composite structure.

In a third embodiment, the present invention comprises a process for modifying a surface covering comprising at least ne reinforcing layer, the modified covering being suitable to accommodate the subsurface movement of a subsurface having an ascertainable subsurface dimensional change when said modified covering is adhered to said subsurface, said process comprising the steps of (a) selecting a surface covering comprising at least one reinforcing layer, the critical buckle strain of said selected covering being less than the subsurface dimensional change; (b) modifying said covering *in situ* such that the critical buckle strain of the modified covering is greater than the initially measured critical buckle strain, but less than the critical buckle strain which would equal or exceed the subsurface dimensional change; (c) selecting a target critical buckle strain which is greater than the subsurface dimensional change; (d) measuring the bending stiffness, relaxed compressive stiffness and basis weight of said modified covering; (e) calculating the adhered basis weight for a covering having the measured bending stiffness, the measured relaxed compressive stiffness, and a critical buckle strain that is equal to the target critical buckle strain; and (f) calculating the minimum adhesive strength necessary to adhere said modified covering to said subsurface whereby when a suitable adhesive having an adhesive strength at least as great as said calculated adhesive strength is selected, said modified structure can be adhered to said subsurface in a manner which will prevent buckling. This embodiment also comprises a process for the manufacture of a composite structure by adhering the modified surface covering to the sub-surface using said adhesive, and the resulting composite structure.

In a fourth embodiment, the present invention relates to a surface covering which is suitable to be adhered with an adhesive to a subsurface without buckling, said surface covering comprising (a) a matrix material, and (b) at least one reinforcing layer disposed therein which has been modified *in situ* such that said surface covering has a critical buckle strain which is less than the subsurface dimensional change of said subsurface, the difference between said buckle strain and said subsurface dimensional change being such that the adhesive strength of a selected adhesive in combination with the basis weight of said surface covering will be sufficient to provide an adhesive bond having a strength which is not less than the adhered basis weight calculated for said surface covering.

In a fifth embodiment, the present invention relates to a composite structure comprising a surface covering, a subsurface and an adhesive which adheres said surface covering and said subsurface together, said surface covering comprising (a) a matrix material, and (b) at least one reinforcing layer disposed therein which has been modified *in situ*, the critical buckle strain of said surface covering being less than the subsurface dimensional change of said subsurface, the difference between said critical buckle strain and said subsurface dimensional change being such that the adhesive strength of said adhesive in combination with the basis weight of said surface covering provides an adhesive bond having a strength which is not less than the adhered basis weight calculated for said surface covering.

As used herein, "loose-lay floor structure" is a floor structure which will lie flat on a stable or unstable subfloor, which will resist doming, curling, buckling, or movement under a rolling load, which preferably has a low structural stability value, and which need not be held in place using adhesives.

As used herein, "accommodating surface covering" is a surface covering which will accommodate or alter its size and shape to match that of an unstable subsurface, even when it is adhered to the subsurface.

As used herein, "subsurface dimensional change" is a measure of the change in length of a subsurface material under the conditions of its environment. This change is expressed herein as change per unit length.

As used herein, "critical buckle strain" is the strain at which a surface covering that is compressed in a planar fashion will buckle.

As used herein, "adhered critical buckle strain" is the strain at which a surface covering that is adhered to a subsurface with a given adhesive will buckle when compressed in a planar fashion. An adhered critical buckle strain value is usually applicable only to the surface covering/adhesive/subsurface system for which it is measured.

As used herein, "relaxed compressive stiffness" is the approximate compressing force per inch (centimeter) of width divided by the induced strain, the value of said relaxed compressive stiffness being projected to a 1000-hour load relaxation and the compressive force being applied in a planar fashion, the measurement being taken in the linear portion of the stress-strain curve.

As used herein, "relaxed tensile stiffness" is the approximate stretching force per inch (centimeter) of width divided by the induced strain, the value of said relaxed tensile stiffness being projected to a 1000-hour load relaxation and the stretching force being applied in a planar fashion, the measurement being taken in the linear portion of the stress-strain curve.

As used herein, "basis weight" is the weight in pounds per square yard (kilograms per square meter) of a surface covering material.

As used herein, the term "adhered basis weight" describes the calculated value which is the minimum strength necessary to adhere a surface covering to a subsurface. This value is a composite of the adhesive strength f an adhesive and the actual basis weight of a material, as will be explained in detail below.

As used herein, "matrix material" comprises all components of a surface covering material excluding the reinforcing material.

As used herein "bending stiffness" is the resistance to bending demonstrated by a surface covering material as measured in inch-pounds (Newton-meters) using a cantilever beam or equivalent method, more especially that described in ASTM D747.

As used herein, "bending resistance" is a material parameter used in the theoretical derivation of the potential energy expression, and characterizes the resistance of the surface covering material to bending.

As used herein, "structural stability" is a measure of the change in length in percent of a surface covering sample which has been heated at 180°F (82.2°C) for six hours and reconditioned at 73.4°F (23°C) and 50% relative humidity for one hour.

A surface covering should be expected to maintain within acceptable limits the shape and dimensions of the subsurface to which it is adhered, and it should not shrink leaving unsightly gaps. This requirement applies regardless of the nature of the subsurface. Therefore, a desirable trait for such a covering is that it have a structural stability under normal conditions of not more than 0.5% and preferably not more than 0.1%.

If the surface to which the surface covering is to be adhered is stable, the characteristics which must be demonstrated by the surface covering are less stringent than for an unstable subsurface since a minimal dimensional change of the surface covering results in minimal planar compressions of the surface covering. Nevertheless, problems can still be encountered which relate to doming, curling, and adhesive failure.

Conversely, unstable subsurfaces such as particleboard dramatically increase the requirements for a surface covering because such subsurfaces tend to expand and contract depending on the temperature and relative humidity conditions within the structure in which the subsurface resides. During winter months, dry furnace-heated air tends to shrink unstable subsurfaces, whereas during humid summer months such subsurfaces tend to expand. A surface covering which is adhered to such a subsurface at its maximum expanded position experiences a variety of stresses when the subsurface changes its dimensions. Thus, many surface coverings having the required structural stability will nevertheless be unable to accommodate these stresses, and will show doming, buckling or other failure of the adhesive bond.

Surprisingly, we have discovered that the principles set forth in the parent application are applicable to a variety of surface coverings such as sheet flooring, floor tile, wall tile, ceiling tile, and the like, wherein these surface coverings are adhered to subsurfaces using an adhesive. The same basic principles which apply to loose-lay flooring also apply to adhered surface coverings. Thus, the terms "subsurface dimensional change" and "accommodating surface covering" have the meanings set forth above.

One major modification in terminology concerns the basis weight. In the case of loose-lay flooring, the flooring is held to the subsurface by its own weight. In a ceiling tile, however, the tile would tend to be separated from the ceiling subsurface by its weight; *i.e.*, gravity would tend to make it fall. This gravitational pull is offset by the adhesive; thus, for purposes of this application of the invention, the adhesive strength of an adhesive should be considered concurrently with the effect of gravity on the basis weight.

Several possible aspects of this are envisaged. For example, if a floor covering is considered, the adhesive strength will be enhanced by the gravitational effect on the covering; if a ceiling covering is considered, the gravitational effect will detract from the adhesive strength; and if a wall covering is considered, the adhesive strength will be relatively unaffected because the gravitational pull will tend to shear in a direction perpendicular to the adhesive strength, a situation which may be ignored for purposes of the present invention.

Because of these considerations, the term "adhered basis weight," as previously defined, is adopted herein. Although the adhered basis weight is a composite of the adhesive strength of an adhesive and the actual basis weight of a surface covering, in actual practice, the adhered basis weight usually will be due almost entirely to the adhesive. For example, a typical floor covering may have a basis weight of two to three pounds per square yard (1 to 2 Kg/m^2), whereas a typical adhesive may have an adhesive strength of two to three pounds per square *inch* (0.4 to 0.6 Kg/cm^2). Accordingly, in many instances the basis weight of the surface covering will be quite small in comparison to the adhesive strength. As will be more fully explained below, the adhered basis weight may be calculated by substituting appropriate values for relaxed compressive stiffness, bending stiffness, and target critical buckle strain into the standard equation, or it may be determined by adding the actual basis weight to, or substracting it from, the adhesive strength.

Other aspects of adhesives which should be considered are their interactions with the surface coverings, the subsurfaces, and the environment in which they are used. Adhesives are often formulated for specific uses. Therefore, for purposes of the present invention, it is assumed that the artisan has the skill to select an adhesive which will show long-term compatibility with the surface covering, the subsurface, and the environment in which it is used. It must be emphasized, however, that the accurate determination of adhesive strength is very important and, for that reason, the directions for use provided by the manufacturer of the adhesive should be precisely followed. Furthermore, the application should be made in the same way for one test and for field installation; *e.g.*, if th directions specify that an adhesive should be applied in a particular manner with a trowel having specified groove dimensions, the application of the adhesive should be performed exactly in that manner both for the test and when the surface covering is

installed over a subsurface. If the installation is not performed in the same way, the predictions obtained according to the present invention may, in many instances, be invalid.

An adhesive which is used to adhere two surfaces together has, after appropriate aging, an initial adherence strength; however, an adhesive bond usually diminishes in strength under load with time and, thus, it may eventually rupture. Because of the potential for a decrease in adhesive strength with time, it has been found that the adhesive strength which should be used when practicing the present invention is the adhesive strength under load in a given environment. This value is defined as the approximate force per square unit of measure (inch^2, yard^2, centimeter^2, or meter^2) at which the adhesive will fail. It preferably is calculated using the bending stiffness, relaxed compressive stiffness and actual basis weight of a given surface covering in combination with the adhered critical buckle strain, as previously defined.

Although adhesive strength may be determined in a number of different ways, the adhesive strength of an adhesive may be conveniently determined for a given surface covering/subsurface system by preparing test strips of surface coverings adhered to subsurface materials which have been conditioned at high relative humidity and temperature. When the adhered systems are subjected to drying conditions at low relative humidity, a strain is induced in the surface covering material. The tendency to buckle caused by the compressive strain which is introduced into the surface covering by subsurface shrinkage is usually compensated for by the adhesive; however, in many situations the adhesive eventually fails and the surface covering buckles. The strain at which this occurs is the adhered critical buckle strain of the system, and it is a measurable value. Consequently, it may be used to calculate the adhesive strength as illustrated in the examples. In appropriate circumstances, the adhesive strength value may also be projected mathematically or graphically from other adhesive strength data.

Three types of rupture are possible, namely, rupture of the adhesive itself, which is a loss of cohesive strength; rupture of the bond between the adhesive and the test subsurface; and rupture of the bond between the test surface backing and the adhesive. A determination of the type of rupture is not a feature of the present invention; however, it is information which is often useful to the artisan.

Because, in this aspect of the invention, the surface coverings are adhered to a subsurface with an adhesive, several of the calculation limits suggested for loose-lay flooring no longer apply. For example, floor tile and wall tile normally would not be rolled, and the suggested bending stiffness upper limit of *ca* 9 inch-pounds (1 Newton-meter) for loose-lay flooring would not be applicable to tile. Bending stiffness values in excess of 20 inch-pounds (2.3 Newton-meters) have been measured for flooring tiles; however, by extending the bending stiffness limits used in the calculations, suitable adhesive strengths have been determined. From this it will be apparent that the suggested ranges used in the calculations may be expanded as necessary to be compatible with the materials under consideration, and that the extensions of these ranges will not adversely affect the calculated results.

The potential energy, π, of a surface covering after buckling may be calculated as described in the parent application according to the formula:

$$\pi=\frac{3C\theta^2}{L_o}+QL_o^2(1-E)\tan\theta+KL_o[1-(1-E)\sec\theta]^2-KL_oE^2$$

where

C=bending resistance

θ=angle of lift-off of the buckle

Q=basis weight

K=relaxed compressive (or tensile) stiffness

L_o=one half the length of the buckled area prior to application of the strain that caused the buckle

E=the compressive strain applied to create the buckle

The bending resistance, C, may be calculated from the bending stiffness measured according to the Olsen Stiffness Test, ANSI/ASTM D747, using the following equation

$$C=\frac{M_wS}{b\phi}$$

where

M_w=the measured bending stiffness

S=the span used in the test

b=the width of the test specimen

ϕ=the angle in radians at which the measurement was taken

The critical buckle strain may be calculated mathematically by applying the principle of minimum potential energy. Bending stiffness values, M_w, are converted to bending resistance values, C. Upon setting the derivatives of π with r spect to θ, and of π with respect to L_o, equal to zero, assigning values for E and Q, and varying C and K within known limits, (or, conversely, varying E and Q and assigning values to C and K), the equation may be solved. For example, this may be accomplished by using the Newton-Rathson Method

of solving non-linear simultaneous equations. Flow charts for computer programs which may be used to effect these calculations are illustrated in Figs. 1A and 1B, and 3A and 3B.

In practicing the present invention, a number of alternatives ar possible, as suggested by the following hypothetical situations: (1) a situation where the surface covering is used as is, and the minimum strength of the adhesive is calculated to ensure firm adherence; (2) a situation where an adhesive is selected and the surface covering is then modified to provide at least minimal performance characteristics in combination with the adhesive; and (3) a situation where a surface covering is selected and modified, and the minimum adhesive requirement is determined so that an appropriate adhesive can be selected. Of course, these situations are provided by way of illustration, and not by way of limitation.

In the first-described hypothetical situation, no modification occurs to the surface covering and it is adhered to the subsurface by using an adhesive having appropriate strength. In the past, the selection of an appropriate adhesive was quite difficult to achieve. As explained above, although an adhesive may initially perform suitably in a given environment, the adhesive may fail under load with time. This may be due to a number of factors, such as changes in the adhesive or adhesive strength caused by the environment (*e.g.*, dampness), or to the buckling tendencies of certain surface coverings when placed over unstable subsurfaces. For these reasons, actual testing of adhered surface covering/subsurface systems will preferably be conducted as previously described during which the climate is changed from humid, summer-like to dry, winter-like conditions. These determinations can be made even for adhesives which change substantially with time, provided that the manner of change can be quantified, and in addition, the present invention will also permit one skilled in the art to find other alternatives if a suitable adhesive cannot be found.

To practice this first-described aspect of the invention, it is first necessary to estimate what subsurface dimensional change is anticipated, and then to assess the performance characteristics of the surface covering by measuring its bending stiffness, basis weight and relaxed tensile stiffness. The critical buckle strain of the covering is then calculated in the usual manner. If the critical buckle strain is greater than the subsurface dimensional change, the situation falls within the scope of the loose-lay flooring situation described in the parent application; *i.e.*, no adhesive would be necessary unless the surface covering were to be used as a ceiling or a wall covering. However, if it is less than the subsurface dimensional change, the necessary minimum adhesive strength can be calculated. This may be done by selecting a target critical buckle strain in excess of the subsurface dimensional change; then, using this target value and the measured bending stiffness and relaxed compressive stiffness values, the adhered basis weight of the structure is calculated.

As applied to this hypothetical situation, the adhered basis weight is a value which incorporates two parameters, the actual basis weight of the surface covering and the minimum required adhesive strength of the adhesive. For example, if the structure is a ceiling tile, the basis weight of the tile would act counter to the adhesive; thus, the minimum adhesive strength required for the adhesive would be the calculated adhered basis weight plus the actual basis weight. Conversely, if the structure is a floor structure, the basis weight would act in concert with the adhesive; thus, the minimum adhesive strength would be the calculated adhered basis weight less the actual basis weight. As an added consideration, it should also be recognized that the calculated adhesive strength is that which is necessary to minimally overcome the factors which would tend to cause the surface covering to separate from the subsurface. Accordingly, in this, as well as other situations, it may be advisable to select an adhesive having a greater-than-required adhesive strength so as to overcome unforeseen factors such as detrimental environmental effects, loss of strength due to plasticizer migration, and the like.

In the second hypothetical situation, the surface covering and the adhesive are selected, and the adhesive strength is determined as previously described. The bending stiffness, basis weight and relaxed compressive stiffness are measured for the unmodified surface covering, and an appropriate target critical buckle strain, in excess of the subsurface dimensional change, is selected. The adhered basis weight is determined depending on the intended use by combining the basis weight and the strength of the adhesive in an appropriate manner, as referred to above. The desired relaxed compressive stiffness can then be calculated using these data. From this information, the surface covering is modified *in situ* to give, ideally, a structure having the calculated relaxed compressive stiffness. Information relating to *in situ* modification was previously described in the parent application. Of course, safety factors may be included in these calculations, as previously suggested.

The third hypothetical situation set forth above relates to a comparable situation, except that the modification is achieved first and then the minimum adhesive strength is determined by making the necessary calculations.

The *in situ* modifications may be performed in a variety of ways. For example, modification may be performed on intact coverings or on partially constructed coverings which are later converted to surface coverings having defined characteristics. Based on practical performance criteria, it appears to be preferred t modify the structure and then apply the back coat because the back coat usually seals the structure. This is especially true where seepage into an open structure might occur. Of course, the required degree of modification may also be determined by estimating the characteristics of individual components or combinations of individual components, or it may be achieved by evaluating composite structures and then back-calculating the characteristics which will be needed in futur structures. As used herein, the term

"*in situ* modification" means modification of a surface covering by changing the structure of its reinforcement when the latter is already in place in an at least partly formed covering. A continuous pattern of modification is one in which there is still a continuum of reinforcing material in the structure. A modified continuous pattern is one in which though there is a continuum the linear nature of its pattern is disrupted, while a discontinuous pattern is one in which there is no continuum of reinforcement. The reader is referred to Figs. 13 and 14 of the parent application for illustrations. Combinations of continuous, modified continuous and discontinuous patterns are also possible.

The present invention has the advantage of providing a relatively reliable way to predict the characteristics of adhered surface coverings, and it also provides guidelines by which the various parameters may be modified so as to predictably alter the characteristics of such surface coverings.

The following examples will be illustrative to demonstrate, but not to limit, the advantages of th present invention.

Example 1

This example illustrates a process for adhering a surface covering to a substrate wherein the surface covering is unmodified and the adhesive is evaluated according to the present invention to ensure that it has adequate adhesive strength.

Four plastisol compositions were prepared having the formulations listed below. The molecular weights of the resins are determinable from the specific viscosities (in parentheses) which were measured according to ASTM D-1243.

Plastisol A

Ingredient	Parts by weight
PVC homopolymer resin, dispersion grade (0.38)	66
PVC homopolymer resin, extender grade (0.35)	34
Monomeric plasticizer	62
Azobisdicarbonamide blowing agent	0.8
Blowing agent activator	0.6
Stabilizer	0.7
Limestone filler	50

Plastisol B

Ingredient	Parts by weight
PVC homopolymer resin, dispersion grade (0.38)	66
PVC homopolymer resin, extender grade (0.35)	34
Monomeric plasticizer	62
Azobisdicarbonamide blowing agent	1.5
Blowing agent activator	0.6
Stabilizer	0.7
Limestone filler	50

Plastisol C

Ingredient	Parts by weight
PVC homopolymer resin, dispersion grade (0.58)	60
PVC homopolymer resin, extender grade (0.35)	40
Monomeric plasticizer	62
Stabilizer	1.5
Pigment	3
Limestone filler	50

Plastisol D

Ingredient	Parts by weight
PVC homopolymer resin, dispersion grade (0.60)	30
PVC homopolymer resin, dispersion grade (0.42)	70
Monomeric plasticizer	45
Viscosity diluent	5
Stabilizer	1

A surface covering was prepared as follows: A roll of #F7155 glass reinforcing material (mat), commercially available from Manville Corporation and having a basis weight of 55 grams per square meter, was used as a reinforcing layer. The glass reinforcing mat was passed through a knife coater where plastisol A was deposited so as to saturate the mat. The knife coater was adjusted to provide a gelled saturated glass layer having a thickness of 0.018 inch (0.46 mm). The structure was passed around a heated drum with the plastisol-coated surface contacting the drum face. As a result of this procedure, which was conducted at a drum temperature of 285°F (141°C), the plastisol was gelled.

A layer of plastisol B 0.005 inch (0.13 mm) thick was applied to the smooth drum-finished surface by reverse roll coating and the coated mat was gelled by heating in an oven at 280°F (138°C). The structure was then fed through a rotogravure printer to deposit a decorative image on the surface of the gelled plastisol B.

After the decorative printing step, a clear layer of plastisol D was applied over the printed surface to provide a protective surface 0.010-inch (0.25 mm) thick. The coated structure was passed through a fusion oven preheated to 380°F (193°C) to: (1) fuse the plastisol layer D, (2) expand the gelled layer of foamable plastisol B to about three times its applied thickness, and (3) expand the gelled, saturated glass layer to about twice its gelled thickness. After exiting from the oven, the fused structure was mechanically embossed to create depressed areas of about 0.010 inch (0.25 mm) in depth into the decorated surface covering. The structure was then completed by applying about 0.008 inch (0.20 mm) of plastisol C to the back of the embossed surface covering the fusing the plastisol around a drum heated at 325°F (163°C) for approximately 15 to 20 seconds. Finally, the completed structure was cooled and fed to a windup device. The measured thicknesses of the various layers of the final structure were as follows:

Layer	Thickness (inch)	Thickness (mm)
Wear surface—plastisol D	0.0104	0.264
Foam formulation—plastisol B	0.0188	0.478
Foam formulation—plastisol A	0.0305	0.775
Back coat—plastisol formulation C	0.0088	0.224
Total thickness	0.0685	1.741

The characteristics of this surface covering, measured as previously described, were as follows:

English units	
Relaxed compressive stiffness	1274 ppiow
Bending stiffness	0.52 inch-pounds
Basis weight	2.7 pounds per sq. yd.
Metric units	
Relaxed compressive stiffness	223,100 N/m
Bending stiffness	0.059 N.m
Basis weight	1.5 Kg/m^2

Using these data, the critical buckle strain expected for this flooring was calculated to be 0.0005.

This material was intended for installation over a subsurface having a subsurface dimensional change of 0.003; accordingly, a target critical buckle strain of 0.0035 was selected for use in the calculation. For this purpose, the computer program previously used was modified to calculate the adhered basis weight, the general modification being illustrated in Figs. 3A and 3B. In addition, the upper basis weight limit was extended to about 150 pounds per square yard (81 Kg/m^2) from the value of 10 pounds per square yard (5 Kg/m^2) previously used for calculating loose-lay flooring parameters. The measured values for the relaxed compressive stiffness and the bending stiffness, and the desired target critical buckle strain of 0.0035 were substituted into the equation and the adhered basis weight was calculated to be 145.4 pounds per square yard (78.9 Kg/m^2).

Because this material was intended for use as a floor covering, the actual basis weight of the material (2.7 pounds per square yard or 1.5 Kg/m^2) would assist in holding the surface covering to the subsurface. Accordingly, the minimum adhesive force necessary to adhere the surface covering to the subsurface was calculated by subtracting 2.7 pounds per yquare yard (1.5 Kg/m^2) from the calculated adhered basis weight of 145.4 pounds per square yard (78.9 Kg/m^2), giving a value of 142.7 pounds per square yard (77.4 Kg/m^2). It is noted that if the surface covering had been intended for use as a ceiling tile, the basis weight would have detracted from the adhesive strength and the minimum adhesive strength would have been obtained by adding the actual basis weight to the adhered basis weight.

Three adhesive candidates were selected for testing. Adhesives would normally be selected for long-term use in a given environment; therefore, in addition to strength, they would also be selected on the basis of their long-term compatibility with the particle board and with the fused PVC backcoat which were used to construct the surface covering/subsurface system. When considered on that basis, the three adhesive candidates normally would not have been selected because their long-term compatibility with these materials is unsatisfactory. However, because the purpose of this example was to illustrate the ability of the present invention to differentiate between adhesives on the basis of strength, and because the incompatibility problems were of little consequence during the term of the test, the incompatibility problems were disregarded.

The selected adhesives were Armstrong's commercial adhesives S-750 and S-242, and an Armstrong experimental adhesive, referred to herein as EXP. The adhesive strength of each of these adhesives was measured in relation to the surface covering materials (the test vinyl backing and the test particle board subsurface) because no single adhesive strength value is applicable to an adhesive; *i.e.,* the adhesive strength of an adhesive often varies depending on the materials with which it is used.

These adhesives were tested in the following manner. Commercial particle board sheets (4 ft.×8 ft.×½" or 1.2 m×2.4 m×1.3 cm) were conditioned at 100°F (37.8°C) and 80% relative humidity (RH) for about two weeks until the length of the boards (measured daily) remained essentially unchanged for three days. Conditioning was then discontinued and the temperature and humidity were changed to essentially ambient conditions (72°F or 22.2°C and 50% RH). Pieces of the test surface covering 14 in. (36 cm) wide and 8 ft. (2.4 m) in length were prepared, and duplicate samples for each adhesive were adhered to the particle board sheets. The ends of the test strips were stapled to the sheets so that the strips would be subjected to a representative compressive stress during the test. The length of each sheet (L_s) was measured at this time.

After the adhesive bond had aged under ambient conditions for one week, the conditions were adjusted to 20% RH and 70°F (21°C). The samples were then monitored as the particle board sheets dried out and contracted, thus placing a compressive force on the eight-foot (2.4 meter) span of the samples. When the surface covering samples buckled, indicating failure of the adhesive bond, the amount of sheet shrinkag for the particle board was m asured by subtracting the sheet length at failure (L_f) from the sheet length at the time th samples were adhered to the sheets (L_s). Th strain at failure was determined according to the equation

$$\frac{L_s - L_f}{L_s} = \text{strain at failure}$$

For the purpose of this aspect of the invention, the strain at failure is referred to as the adhered critical buckle strain, which was defined earlier.

It was noted that all three adhesives failed differently during the test: The S-750 adhesive lost its cohesive strength and left adhesive residue on both surfaces; the S-242 adhesive remained on the particle board leading the backing essentially free of adhesive residue; and the EXP adhesive remained on th surface of the backing and left essentially no residue on the particle board.

An average adhered critical buckle strain was determined for each system. By inserting this average value, and the relaxed compressive stiffness and bending stiffness values for the test surface covering (above), into the equation, the adhered basis weight for each system was calculated using the computer program illustrated in Figs. 3A and 3B. Because the test surface was a floor covering, the actual basis weight was subtracted from each value to give the following adhesive strengths:

EXP=13.0 lb./yd.^{2} or 7.1 Kg/m^2
S-750=129.6 lb./yd.^{2} or 70.3 Kg/m^2
S-242=180.5 lb./yd.^{2} or 97.9 Kg/m^2

These values indicated that the S-750 and EXP adhesives would not perform satisfactorily because their adhesive strengths were less than the minimum strength as determined from the earlier calculation (142.7 pounds per square yard or 77.4 Kg/m^2). The third adhesive S-242, had an adhesive strength which was in excess of the calculated value, indicating that it would be suitable to adhere the test surface covering to the particle board subsurface.

To test the validity of this determination, particle board sheets were conditioned in an environmental test chamber at 80% RH and 72°F (22.2°C) for four weeks, after which a 12 ft.×10 ft. (3.7 m×3.0 m) subsurface was built over a plywood support surface according to standard NPA installation directions. A 12 ft.×10 ft. (3.7 m×3.0 m) piece of surface covering was then adhered to the subsurface using the S-242 adhesive. It is emphasized that the adhesive was applied exactly as it was for the above-described strip test, and exactly according to the application directions.

After the adhesive had aged, a six-week drying cycle was commenced to induce the particle board to shrink by its subsurface dimensional change factor of 0.003. Although certain minor deficiencies were noted during the test, these were not attributable to the present invention, and the installation was deemed to have performed satisfactorily. As an example of one deficiency, surface coverings of the type illustrated in this Example 1 are commonly affected by the presence of bubbles, or air pockets, between the surface covering and the subsurface. These pockets prevent adequate adhesion in certain small areas which eventually result in the presence of noticeable bubbles or blisters. These defects are attributable to the manner in which the test materials are installed and/or to a lack of initial adhesion, and are not attributable to the invention itself.

Example 2

This example will illustrate the situation where an adhesive is selected and a selected surface covering is modified so that it will be suitable for use with the adhesive when adhered to a given subsurface.

A surface covering was prepared essentially as described in Example 1, except that the glass mat was modified *in situ* after the embossing step, before the backing coat (plastisol C) was applied.

This surface covering was selected for use over a particle board subsurface having a subsurface dimensional change of 0.0015. The EXP adhesive was selected and the adhesive strength of this adhesive was determined as described in Example 1 to be 13.0 pounds per square yard (7.1 Kg/m^2).

The basis weight, bending stiffness and relaxed compressive stiffness were measured for the selected surface covering to give the following values:

English units	
Relaxed compressive stiffness	1,274 ppiow
Basis weight	2.6 pounds per sq. yd.
Bending stiffness	0.63 inch pounds
Metric units	
Relaxed compressive stiffness	223,100 N/m
Basis weight	1.4 Kg/m^2
Bending stiffness	0.071 N.m

From these data, the unmodified surface covering was calculated to have a critical buckle strain of 0.0005. A target critical buckle strain of 0.002 was selected for use over the subsurface having an expected subsurface dimensional change of 0.0015.

The surface covering in this example was also intended for use as a floor covering. Accordingly, the adhered basis weight was calculated by adding the adhesive strength of 13.0 pounds per square yard (7.1 Kg/m) for the adhesive and the actual basis weight (2.6 pounds per square yard or 1.4 Kg/m²) of the surface covering, giving a value of 15.6 pounds per square yard (8.5 Kg/m²).

For this example, the computer program illustrated in Figs. 1A and 1B was used to calculate the relaxed compressive stiffness, except that the upper limit for the basis weight was expanded such that it was in excess of the calculated adhered basis weight of 15.6 pounds per square yard (8.5 Kg/m²). The measured bending stiffness, the adhered basis weight, and the target critical buckle strain were substituted into the equation to provide a calculated relaxed compressive stiffness value of 648 ppiow (113,500 N/m). Accordingly, modification of the surface covering was required in order to reduce the relaxed compressiv stiffness from the initially measured value of 1,274 ppiow (223,100 N/m) to a value less than or equal to 648 ppiow (113,500 N/m).

The surface covering was modified by cutting 1-inch (2.5 cm) diamond-shaped elements into the reinforcing layer from the back of the surface covering. The partial structure, was fed upside down at room temperature through a pair of pinch rolls, the upper roll being an embossing roll especially designed to perforate the glass reinforcement and the lower roll being a smooth steel back-up roll. The roll pressure was adjustable such that modification could be varied from slight modification at low pressure t substantial modification at higher pressure. For purposes of the present test, the nip pressure was adjusted to 120 pounds per lineal inch (21.4 Kg/cm).

The upper embossing roll was designed with a pattern comparable to that shown in Fig. 2; however, the pattern was angled at 45 degrees to the machine direction to create a diamond-shaped element pattern. The raised portions of the embossing roll were 0.045 inch (1.14 mm) high and 0.025 inch (0.64 mm) wide.

After the material had passed through the nip, a test piece was placed in tetrahydrofuran solvent to dissolve the polymeric material and recover the modified glass mat. Visual inspection of the mat showed that the 1-inch (2.5 cm) diamond elements were almost completely separated from the continuum of glass, but a few strands still held the elements in place. The structure was completed as described in Example 1 through application of plastisol coat C. The relaxed compressive stiffness of the completed, modified structure was found to be 623 ppiow (109,100 N/m).

To evaluate the effect of this modification, the surface covering was installed over the selected particle board subsurface in the manner described in Example 1 and the adhered system was subjected to a six-week cycle during which the particle board shrank by about a factor of 0.0015, the expected subfloor dimensional change value. The installation performed satisfactorily and there was no evidence of buckling.

Example 3

This example will illustrate the modification of a surface covering, followed by selection of an appropriate adhesive which is compatible with the characteristics of the modified covering.

A surface covering was partially prepared, modified, and then completed as described in Example 2. The following physical properties were measured for the modified structure:

English units	
Relaxed compressive stiffness	520 ppiow
Bending stiffness	0.58 inch-pounds
Basis weight	2.6 pounds per sq. yd.
Metric units	
Relaxed compressive stiffness	91,100 N/m
Bending stiffness	0.066 N.m
Basis weight	1.4 Kg/m²

Using these data, a critical buckle strain of 0.001 was obtained for the *in situ* modified structure. A target critical buckle strain of 0.0035 was selected for use in the calculation based on a proposed particle board subfloor having a subfloor dimensional change of 0.003.

The modified computer program illustrated in Figs. 3A and 3B was used to calculate the adhered basis weight by inserting the measured relaxed compressive stiffness and bending stiffness values, and the target critical buckle strain of 0.0035, into the equation. The adhered basis weight was calculated to be 35.8 pounds per square yard (19.4 Kg/m²). This surface covering was also intended for use as a floor covering. Accordingly, the measured basis weight of 2.6 pounds per squar yard (1.4 Kg/m²) was subtracted from the calculated adhered basis w ight of 35.8 pounds per square yard (19.4 Kg/m²) in order to give a required minimum adhesive strength of 33.2 pounds per square yard (18.0 Kg/m²) for the adhesive.

The adhesive strengths for each of th three adhesives used in Example 1 were also applicable in this example because the materials which were being adhered together were identical. Accordingly, the above

calculation indicates that two of the three adhesives (S-242 and S-750) would be suitable to adhere the modified structure in this example to the intended subsurface.

A 10 ft.×12 ft. (3.0 m×3.7 m) surface covering sample was adhered to a particle board subsurface using the S-750 adhesive and tested as described above for six weeks under simulated environmental test conditions which would induce a subfloor dimensional change of 0.003. Satisfactory performance was found and there was no indication of buckling.

Our invention is not restricted solely to the descriptions and illustrations provided above, but encompasses all modifications envisaged by the following claims.

Claims

1. A process for adhering a surface covering to a subsurface having an ascertainable subsurface dimensional change such that said surface covering will accommodate subsurface movement without buckling, said process comprising the steps of

(a) selecting a surface covering, the critical buckle strain of the selected covering being less than the subsurface dimensional change;

(b) selecting a target critical buckle strain which is greater than the subsurface dimensional change;

(c) measuring the relaxed compressive stiffness, the bending stiffness and the basis weight of said selected covering;

(d) calculating the adhered basis weight for a surface covering having the measured bending stiffness, the measured relaxed compressive stiffness, and a critical buckle strain that is equal to the target critical buckle strain;

(e) calculating the minimum adhesive strength which will be necessary to adhere said surface covering to said subsurface in a manner which will prevent buckling;

(f) selecting a suitable adhesive, and

(g) adhering said surface covering to said subsurface.

2. A process for modifying a surface covering comprising at least one reinforcing layer whereby it can be adhered without buckling to a subsurface having an ascertainable subsurface dimensional change, said process comprising the steps of

(a) selecting a surface covering comprising at least one reinforcing layer, the critical buckle strain of said selected covering being less than the subsurface dimensional change;

(b) selecting an adhesive having a determined adhesive strength;

(c) measuring the basis weight, the bending stiffness and the relaxed compressive stiffness of said selected covering;

(d) selecting a target critical buckle strain which is greater than the subfloor dimensional change;

(e) calculating the adhered basis weight which would be obtained if said selected covering were adhered to said subsurface using said adhesive;

(f) calculating the relaxed compressive stiffness for a modified surface covering having the measured bending stiffness, the calculated adhered basis weight, and a critical buckle strain which is equal to the target critical buckle strain, and

(g) modifying said covering *in situ* such that it has a relaxed compressive stiffness value which is not greater than the calculated relaxed compressive stiffness value, whereby when the modified surface covering is adhered to said subsurface using said adhesive, it will accommodate subsurface movement without buckling.

3. A process for modifying a surface covering comprising at least one reinforcing layer, the modified covering being suitable to accommodate the subsurface movement of a subsurface having an ascertainable subsurface dimensional change when said modified covering is adhered to said subsurface, said process comprising the steps of

(a) selecting a surface covering comprising at least one reinforcing layer, the critical buckle strain of said selected covering being less than the subsurface dimensional change;

(b) modifying said covering *in situ* such that the critical buckle strain of the modified covering is greater than the initially measured critical buckle strain, but less than the critical buckle strain which would equal or exceed the subsurface dimensional change;

(c) selecting a target critical buckle strain which is greater than the subsurface dimensional change;

(d) measuring the bending stiffness, relaxed compressive stiffness and basis weight of said modified covering;

(e) calculating the adhered basis weight for a covering having the measured bending stiffness, the measured relaxed compressive stiffness, and a critical buckle strain that is equal to the target critical buckle strain; and

(f) calculating the minimum adhesive strength necessary to adhere said modified covering to said subsurface, whereby when a suitable adhesive having an adhesive strength at least as great as said calculated adhesive strength is selected; said modified structur can be adhered to said subsurface in a manner which will prevent buckling.

4. A surface covering which is suitable to be adhered with an adhesive to a subsurface without buckling, said surface covering comprising

(a) a matrix material, and

(b) at least one reinforcing layer disposed therein which has been modified *in situ* such that said surface covering has a critical buckle strain which is less than the subsurface dimensional change of said subsurface, the difference between said critical buckle strain and said subsurface dimensional change being such that the adhesive strength of a selected adhesive in combination with the basis weight of said surface covering will be sufficient to provide an adhesive bond having a strength which is not less than the adhered basis weight calculated for said surface covering.

5. The surface covering as set forth in claim 4 wherein said surface covering is obtained by the process set forth in claim 2 or claim 3.

6. A composite structure comprising a surface covering, a subsurface and an adhesive which adheres said surface covering and said subsurface together, said surface covering comprising

(a) a matrix material, and

(b) at least one reinforcing layer disposed therein which has been modified *in situ*, the critical buckle strain of said surface covering being less than the subsurface dimensional change of said subsurface, the difference between said critical buckle strain and said subsurface dimensional change being such that the adhesive strength of said adhesive in combination with the basis weight of said surface covering provides an adhesive bond having a strength which is not less than the adhered basis weight calculated for said surface covering.

7. The composite structure as set forth in claim 6 wherein said composite structure is obtained by the process set forth in claim 2 or claim 3 and subsequently adhering said surface covering to said subsurface using said selected adhesive.

8. The process as set forth in claim 1 wherein said surface covering comprises at least one reinforcing layer.

9. The process, surface covering or composite structure as set forth in any one of claims 2 to 7 wherein said modification is achieved using a continuous modification pattern.

10. The process, surface covering or composite structure as set forth in any one of claims 2 to 7 wherein said modification is achieved using a modified continuous pattern.

11. The process, surface covering or composite structure as set forth in any one of claims 2 to 7 wherein said modification is achieved using a discontinuous modification pattern.

12. The process, surface covering or composite structure as set forth in any one of claims 2 to 7 wherein said modification is achieved using a discontinuous modification pattern in combination with a continuous or a modified continuous pattern.

13. The process, surface covering or composite structure as set forth in any one of claims 2 to 12 wherein said reinforcing layer is a glass reinforcing layer.

14. The process, surface covering or composite structure as set forth in any one of claims 2 to 13 wherein each said reinforcing layer has a basis weight of from 15 to 160 grams per square meter, especially from 20 to 80 grams per square meter.

Patentansprüche

1. Verfahren zum haftenden Befestigen eines Flächenbelags an einer Unterfläche, die eine feststellbare Unterflächendimensionsänderung aufweist, derart, daß der Flächenbelag eine Unterflächenbewegung ohne Beulen aufnimmt, wobei dieses Verfahren die Schritte aufweist

(a) Wahl eines Flächenbelags, wobei die kritische Beulbelastung des gewählten Belags geringer ist als die Unterflächenabmessungsänderung;

(b) Wahl einer kritischen Soll-Beulbelastung, die grösser ist als die Unterflächenabmessungsänderung;

(c) Messen der entspannten Drucksteifigkeit, der Biegesteifigkeit und des Basisgewichts des gewählten Belags;

(d) Berechnen des Haft-Basisgewichts für einen Flächenbelag, der die gemessene Biegesteifigkeit, die gemessene entspannte Drucksteifigkeit und eine kritische Beulbelastung aufweist, die gleich der kritischen Soll-Beulbelastung ist;

(e) Berechnen der minimalen Haftfestigkeit, die erforderlich ist, damit der Flächenbelag an der Unterfläche so haftet, daß ein Beulen verhindert wird;

(f) Wahl eines geeigneten Klebstoffs und

(g) Verkleben des Flächenbelags mit der Unterfläche.

2. Verfahren zum Modifizieren eines Flächenbelags, der wenigstens eine Verstärkungsschicht aufweist, wodurch er haftend ohne Beulen mit einer Unterfläche verbunden werden kann, die eine bestimmbare Unterflächenabmessungsänderung hat, wobei das Verfahren die Schritte aufweist:

(a) Wahl eines Flächenbelags, der wenigstens eine Verstärkungsschicht aufweist, wobei die kritische Beulbelastung des ausgewählten Belags kleiner ist als die Unterflächenabmessungsänderung;

(b) Wahl eines Klebstoffs, der eine bestimmte Haftfestigkeit hat;

(c) Messen des Basisgewichts, der Biegesteifigk it und der entspannten Drucksteifigkeit des ausgewählten Belags;

(d) Wahl einer kritischen Soll-Beulbelastung, die gr¨ßer ist als die Unterbodenabmessungsänderung;

(e) Berechnen des Haft-Basisgewichts, das man erhalt n würde, wenn der ausgewählte Belag unter Verwendung des Klebstoffs mit der Unterfläche verklebt worden wäre;

(f) Berechnen der entspannten Drucksteifigkeit für einen modifizierten Flächenbelag, der die gemessene Biegesteifigkeit, das berechnete Haftbasisgewicht und eine kritische Beulbelastung hat, die gleich der kritischen Soll-Beulbelastung ist, und

(g) Modifizieren des Belags in situ derart, daß er einen Wert der entspannten Drucksteifigkeit hat, der nicht größer ist als der berechnete Wert der entspannten Drucksteifigkeit, wodurch dann, wenn der modifizierte Flächenbelag mit der Unterfläche unter Verwendung des Klebstoffs verklebt ist, er die Unterflächenbewegung ohne Beulen aufnimmt.

3. Verfahren zum Modifizieren eines Flächenbelags, der wenigstens eine Verstärkungsschicht aufweist, wobei der modifizierte Belag geeignet ist, die Unterflächenbewegung einer Unterfläche aufzunehmen, welche eine feststellbare Unterflächenabmessungsänderung aufweist, wenn der modifizierte Belag mit der Unterfläche verklebt wird, wobei das Verfahren die Schritte aufweist:

(a) Wahl eines Flächenbelags, der wenigstens eine Verstärkungsschicht aufweist, wobei die kritische Beulbelastung des gewählten Belags kleiner als die Unterflächenabmessungsänderung ist;

(b) Modifizieren des Belags in situ derart, daß die kritische Beulbelastung des modifizierten Belags größer ist als die anfänglich gemessene kritische Beulbelastung, jedoch kleiner als die kritische Beulbelastung, die gleich der Unterflächenabmessungsänderung wäre oder diese überschreiten würde;

(c) Wahl einer kritischen Soll-Beulbelastung, die größer ist als die Unterflächenabmessungsänderung;

(d) Messen der Biegesteifigkeit, der entspannten Drucksteifigkeit und des Basisgewichts des modifizierten Belags;

(e) Berechnen des Haftbasisgewichts für einen Belag, der die gemessene Biegesteifigkeit, die gemessene entspannte Drucksteifigkeit und eine kritische Beulbelastung hat, die gleich der kritischen Soll-Beulbelastung ist, und

(f) Berechnen der minimalen Haftfestigkeit, die erforderlich ist, um den modifizierten Belag mit der Unterfläche zu verkleben, wodurch dann, wenn ein geeigneter Klebstoff ausgewählt wird, der eine Haftfestigkeit hat, die wenigstens so groß wie die berechnete Haftfestigkeit ist, der modifizierte Aufbau dann mit der Unterfläche auf eine Art verklebt werden kann, die ein Beulen verhindert.

4. Flächenbelag, der für ein Ankleben mit einem Klebstoff an einer Unterfläche ohne Beulen geeignet ist, wobei der Flächenbelag aufweist:

(a) ein Matrixmaterial und

(b) wenigstens eine Verstärkungsschicht, die darin angeordnet ist und die in situ derart modifiziert worden ist, daß der Flächenbelag eine kritische Beulbelastung hat, die kleiner als die Unterflächenabmessungsänderung der Unterfläche ist, wobei die Differenz zwischen der kritischen Beulbelastung und der Unterflächenabmessungsänderung derart ist, daß die Haftfestigkeit eines gewählten Klebstoffs in Kombination mit dem Basisgewicht des Flächenbelags ausreicht, eine Klebebindung zu schaffen, die eine Festigkeit hat, die nicht geringer ist als das Haftbasisgewicht, das für den Flächenbelag berechnet wurde.

5. Flächenbelag nach Anspruch 4, wobei der Flächenbelag durch das Verfahren nach Anspruch 2 oder 3 erhalten wird.

6. Verbundaufbau aus einem Flächenbelag, einer Unterfläche und einem Klebstoff, der den Flächenbelag mit der Unterfläche verklebt, wobei der Flächenbelag aufweist

(a) ein Matrixmaterial und

(b) wenigstens eine darin angeordnete Verstärkungsschicht, die in situ modifiziert worden ist, wobei die kritische Beulbelastung des Flächenbelags kleiner als die Unterflächenabmessungsänderung der Unterfläche ist und die Differenz zwischen der kritisichen Beulbelastung und der Unterflächenabmessungsänderung so beschaffen ist, daß die Haftfestigkeit des Klebstoffs in Kombination mit dem Basisgewicht des Flächenbelags eine Haftverbindung ergibt, die eine Festigkeit hat, welche nicht kleiner als das Haftbasisgewicht ist, das für den Flächenbelag berechnet worden ist.

7. Verbundaufbau nach Anspruch 6, wobei der Verbundaufbau nach dem Verfahren nach Anspruch 2 oder Anspruch 3 erhalten wird und darauffolgend der Flächenbelag mit der Unterfläche unter Verwendung des ausgewählten Klebstoffs verklebt wird.

8. Verfahren nach Anspruch 1, bei welchem der Flächenbelag wenigstens eine Verstärkungsschicht aufweist.

9. Verfahren, Flächenbelag oder Verbundaufbau nach einem der Ansprüche 2 bis 7, bei welchem die Modifizierung unter Verwendung eines kontinuierlichen Modifizierungsmusters erreicht wird.

10. Verfahren, Flächenbelag oder Verbundaufbau nach einem der Ansprüche 2 bis 7, bei welchen die Modifizierung unter Verwendung eines modifizierten kontinuierlichen Musters erreicht wird.

11. Verfahren, Flächenbelag oder Verbundaufbau nach einem der Ansprüche 2 bis 7, bei welchen die Modifizierung unter Verwendung eines diskontinuierlichen Modifizierungsmusters erreicht wird.

12. Verfahren, Flächenbelag oder Verbundaufbau nach einem der Ansprüche 2 bis 7, bei welchen die Modifizierung unter Verwendung eines diskontinuierlichen Modifizierungsmusters in Kombination mit einem kontinuierlichen oder einem modifizierten kontinuierlichen Muster erreicht wird.

13. Verfahren, Flächenbelag oder Verbundaufbau nach einem der Ansprüche 2 bis 12, bei welchen die Verstärkungsschicht eine Glas-Verstärkungsschicht ist.

14. Verfahren, Flächenbelag oder Verbundaufbau nach einem der Ansprüche 2 bis 13, bei welchen die Verstärkungsschicht ein Basisgewicht von 15 bis 160 g/m², insbesondere von 20 bis 80 g/m², hat.

Revendicati ns

1. Procédé permettant de coller un revêtement de surface sur une surface sous-jacente offrant une variation de dimension pouvant être constatée, de façon telle que ce revêtement de surface absorbe un déplacement de cette surface sous-jacente sans être l'objet d'un flambage, ce procédé consistant:

(a) à choisir un revêtement de surface, la contrainte critique de flambage du revêtement choisi étant inférieure à la variation de dimension de la surface sous-jacente,

(b) à choisir une contrainte critique de flambage cible qui soit supérieure à la variation de dimension de la surface sous-jacente

(c) à mesurer la rigidité à la compression en relaxation, la rigidité à la flexion et le poids de base du revêtement choisi,

(d) à calculer le poids de base à l'état collé pour un revêtement de surface offrant la rigidité à la flexion mesurée, la rigidité à la compression en relaxation mesurée, et une contrainte critique de flambage qui serait égale à la contrainte critique de flambage cible,

(e) à calculer la résistance minimale de collage qui serait nécessaire pour coller ledit revêtement de surface sur ladite surface sous-jacente d'une manière qui empêcherait un flambage,

(f) à choisir une substance adhésive et

(g) à coller ledit revêtement de surface sur ladite surface sous-jacente.

2. Procédé permettant de modifier un revêtement de surface comprenant au moins une couche de renforcement, de façon qu'il puisse être collé sans faire l'objet d'un flambage sur une surface sous-jacente offrant une variation de dimension pouvant être constatée, ce procédé consistant:

(a) à choisir un revêtement de surface comportant au moins une couche de renforcement, la contrainte critique de flambage du revêtement choisi étant inférieure à la variation de dimension de la surface sous-jacente,

(b) à choisir une substance adhésive offrant une force de collage déterminée,

(c) à mesurer le poids de base, la rigidité de la flexion et la rigidité à la compression en relaxation du revêtement choisi,

(d) à choisir une contrainte critique de flambage cible qui est supérieure à la variation de dimension du sous-plancher,

(e) à calculer le poids de base à l'état collé qui serait obtenu si le revêtement choisi était collé sur ladite surface sousjacente en utilisant ladite substance adhésive,

(f) à calculer la rigidité à la compression en relaxation pour un revêtement de surface modifié offrant la rigidité à la flexion mesurée, le poids de base à l'état collé calculé, et une contrainte critique de flambage qui serait égale à la contrainte critique de flambage cible et

(g) à modifier le revêtement in situ d'une façon telle qu'il présente une valeur de rigidité à la compression en relaxation qui ne soit pas supérieure à la valeur de rigidité à la compression en relaxation calculée, de sorte que, lorsque le revêtement de surface modifié est collé sur ladite surface sous-jacente en utilisant ladite substance adhésive, il s'adapte à un déplacement de cette surface sous-jacente sans faire l'objet d'un flambage.

3. Procédé permettant de modifier un revêtement de surface comprenant au moins une couche de renforcement, le revêtement modifié convenant pour s'adapter au déplacement d'une surface sousjacente offrant une variation de dimension pouvant être constatée lorsque ce revêtement modifié est collé sur cette surface sousjacente, ce procédé consistant:

(a) à choisir un revêtement de surface comportant au moins une couche de renforcement, la contrainte critique de flambage du revêtement choisi étant inférieure à la variation de dimension de la surface sous-jacente,

(b) à modifier ce revêtement *in situ* de façon telle que la contrainte critique de flambage du revêtement modifié soit supérieure à la contrainte critique de flambage initialement mesurée, mais inférieure à la contrainte critique de flambage qui serait égale à la variation de dimension de la surface sous-jacente ou la dépasserait,

(c) à choisir une contrainte critique de flambage cible qui est supérieure à la variation de dimension de la surface sous-jacente,

(d) à mesurer la rigidité à la flexion, la rigidité à la compression en relaxation, et le poids de base du revêtement modifié,

(e) à calculer le poids de base à l'état collé pour un revêtement offrant la rigidité à la flexion mesurée, la rigidité à la compression en relaxation mesurée, et une contrainte critique de flambage qui serait égale à la contrainte critique de flambage cible et

(f) à calculer la résistance minimale de collage qui serait nécessaire pour coller ledit revêtement modifié sur ladite surface sous-jacente, de sorte que, lorsque c'est une substance adhésive appropriée offrant une force de collage au moins aussi grande que la force de collage calculée, qui est choisie, la structure modifiée peut être collée sur ladite surface sous-jacente d'une manière qui empêche un flambage.

4. Revêtement de surface qui convient pour être collé sur une surface sous-jacente à l'aide d'une substance adhésive sans faire l'objet d'un flambage, ce revêtement de surface comprenant:

(a) un matériau formant matrice et

(b) au moins une couche de renforcement qui est disposée dans celle-ci et qui a été modifiée *in situ* d'une façon telle que le revêtement de surface offre une contrainte critique de flambage qui est inférieure à la variation de dimension de la surface sous-jacente, la différence entre cette contrainte de flambage et la variation de dimension de la surface sous-jacente étant telle que la force de collage d'une substance adhésive choisie en combinaison avec le poids de base du revêtement de surface est suffisante pour assurer une liaison adhésive offrant une force qui n'est pas inférieure au poids de base à l'état collé, calculé pour le revêtement de surface.

5. Revêtement de surface suivant la revendication 4, dans lequel ce revêtement de surface est obtenu à l'aide du procédé suivant la revendication 2 ou la revendication 3.

6. Structure composite comprenant un revêtement de surface, une surface sous-jacente et une substance adhésive qui colle entre eux ce revêtement de surface et cette surface sous-jacente, ce revêtement de surface comprenant:

(a) un matériau formant matrice et

(b) au moins une couche de renforcement qui est disposée dans celle-ci et qui a été modifiée *in situ*. la contrainte critique de flambage du revêtement de surface étant inférieure à la variation de dimension de la surface sous-jacente, la différence entre cette contrainte critique de flambage et cette variation de dimension de la surface sous-jacente étant telle que la résistance de collage de ladite substance adhésive en combinaison avec le poids de base du revêtement de surface est suffisante pour assurer une liaison adhésive offrant une force qui n'est pas inférieure au poids de base à l'état collé, calculé pour le revêtement de surface.

7. Structure composite suivant la revendication 6, dans laquelle cette structure composite est obtenue à l'aide du procédé suivant la revendication 2 ou la revendication 3 et en collant par la suite le revêtement de surface sur la surface sous-jacente à l'aide de la substance adhésive choisie.

8. Procédé suivant la revendication 1, selon lequel le revêtement de surface comprend au moins une couche de renforcement.

9. Procédé, revêtement de surface ou structure composite suivant l'une quelconque des revendications 2 à 7, dans lesquels la modification s'obtient en utilisant un motif de modification continu.

10. Procédé, revêtement de surface ou structure composite suivant l'une quelconque des revendications 2 à 7, dans lesquels la modification s'obtient en utilisant un motif continu modifié.

11. Procédé, revêtement de surface ou structure composite suivant l'une quelconque des revendications 2 à 7, dans lesquels la modification s'obtient en utilisant un motif de modification discontinu.

12. Procédé, revêtement de surface ou structure composite suivant l'une quelconque des revendications 2 à 7, dans lesquels la modification s'obtient en utilisant un motif de modification discontinu en combinaison avec un motif continu ou continu modifié.

13. Procédé, revêtement de surface ou structure composite suivant l'une quelconque des revendications 2 à 12, dans lesquels la couche de renforcement est une couche de renforcement en verre.

14. Procédé, revêtement de surface ou structure composite suivant l'une quelconque des revendications 2 à 13, dans lesquels chaque couche de renforcement offre un poids de base de 15 à 160 grammes par mètre carré, plus particulièrement de 20 à 80 grammes par mètre carré.

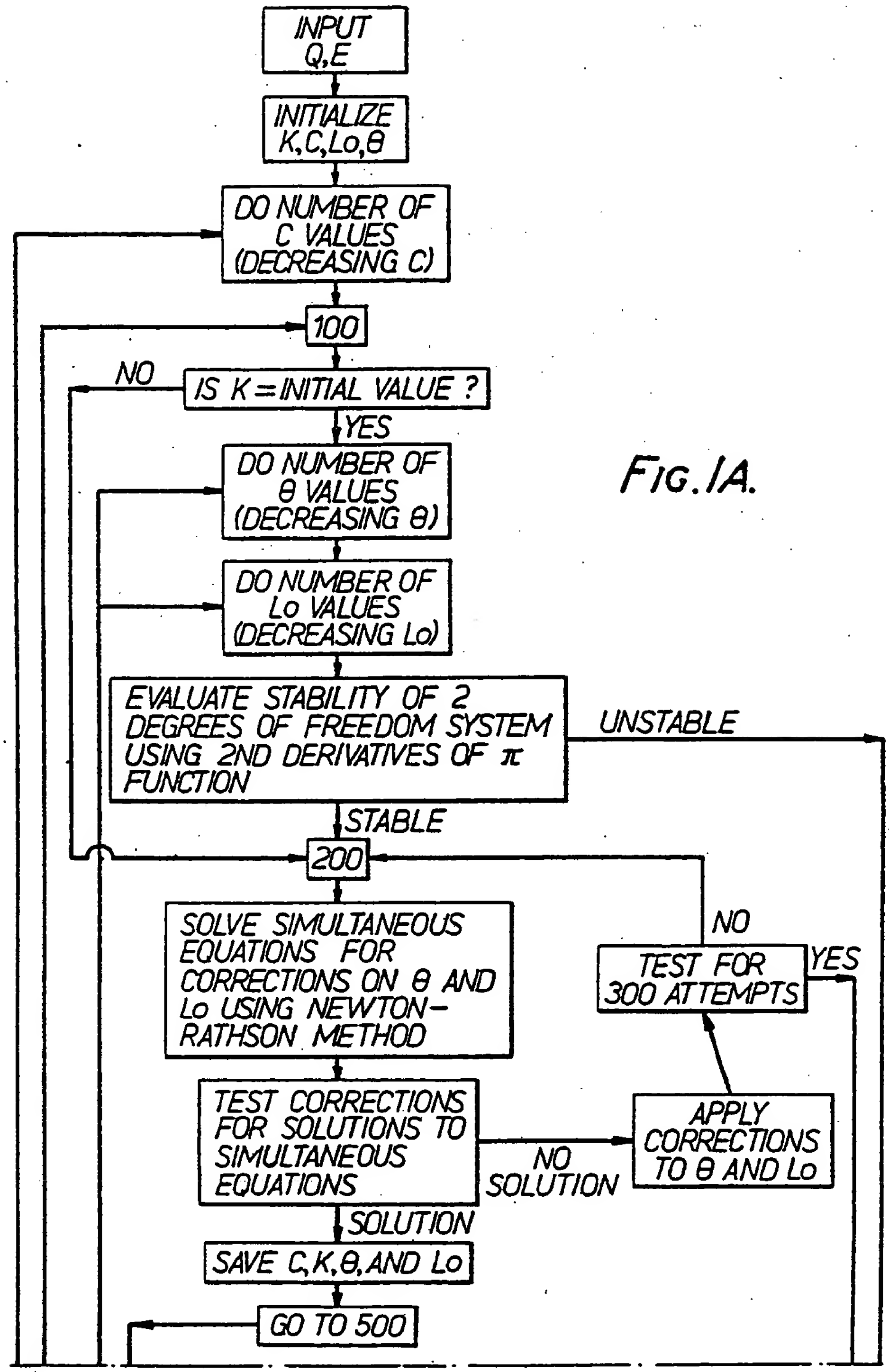
INPUT Q,E
INITIALIZE K,C,Lo,θ
DO NUMBER OF C VALUES (DECREASING C)
100
NO
IS K=INITIAL VALUE ?
YES
DO NUMBER OF θ VALUES (DECREASING θ)
DO NUMBER OF Lo VALUES (DECREASING Lo)
EVALUATE STABILITY OF 2 DEGREES OF FREEDOM SYSTEM USING 2ND DERIVATIVES OF π FUNCTION
UNSTABLE
STABLE
200
NO
TEST FOR 300 ATTEMPTS
YES
SOLVE SIMULTANEOUS EQUATIONS FOR CORRECTIONS ON θ AND Lo USING NEWTON-RATHSON METHOD
TEST CORRECTIONS FOR SOLUTIONS TO SIMULTANEOUS EQUATIONS
NO SOLUTION
APPLY CORRECTIONS TO θ AND Lo
SOLUTION
SAVE C,K,θ, AND Lo
GO TO 500

FIG. 1A.

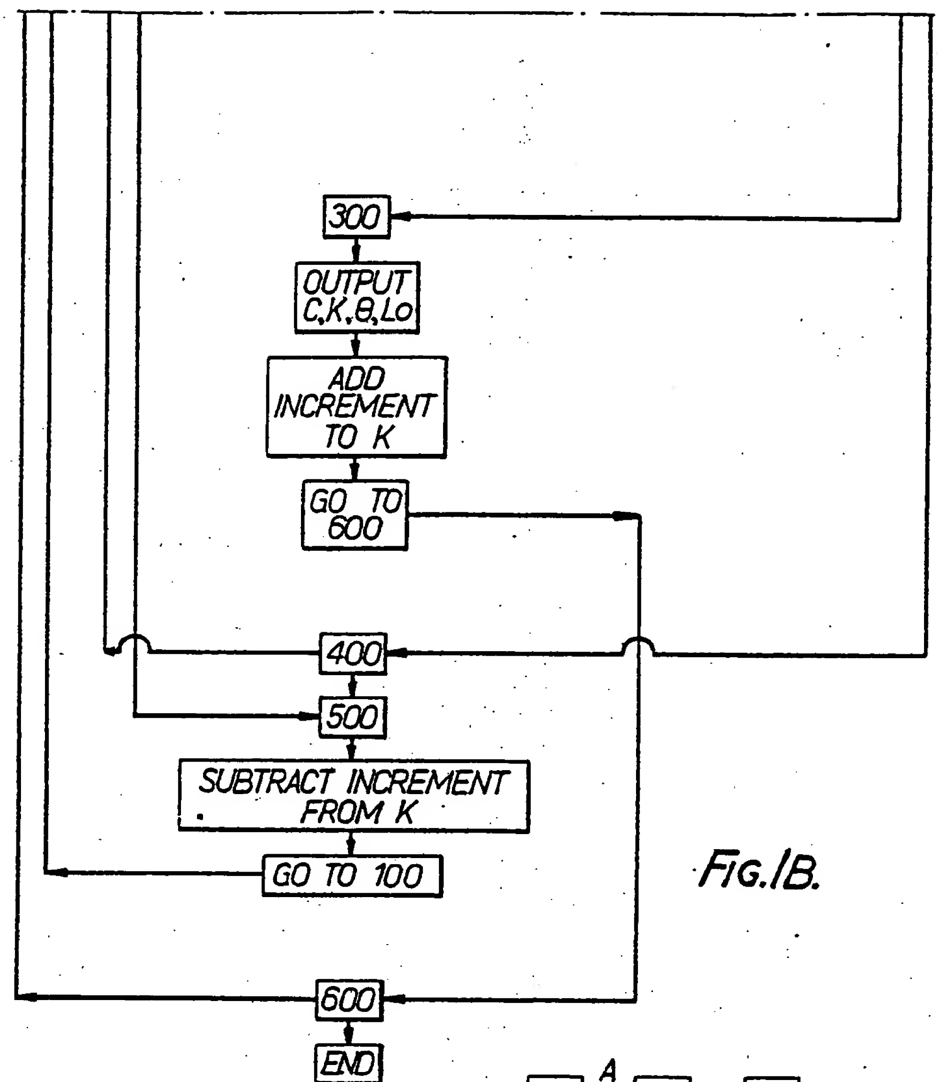
300
OUTPUT C,K,θ,Lo
ADD INCREMENT TO K
GO TO 600
400
500
SUBTRACT INCREMENT FROM K
GO TO 100
600
END

FIG. 1B.

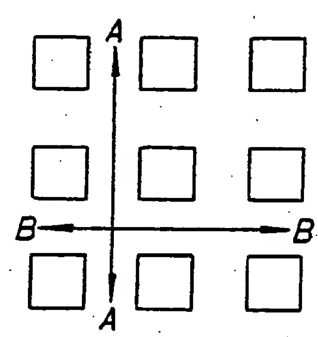
A
B
B
A

FIG. 2.

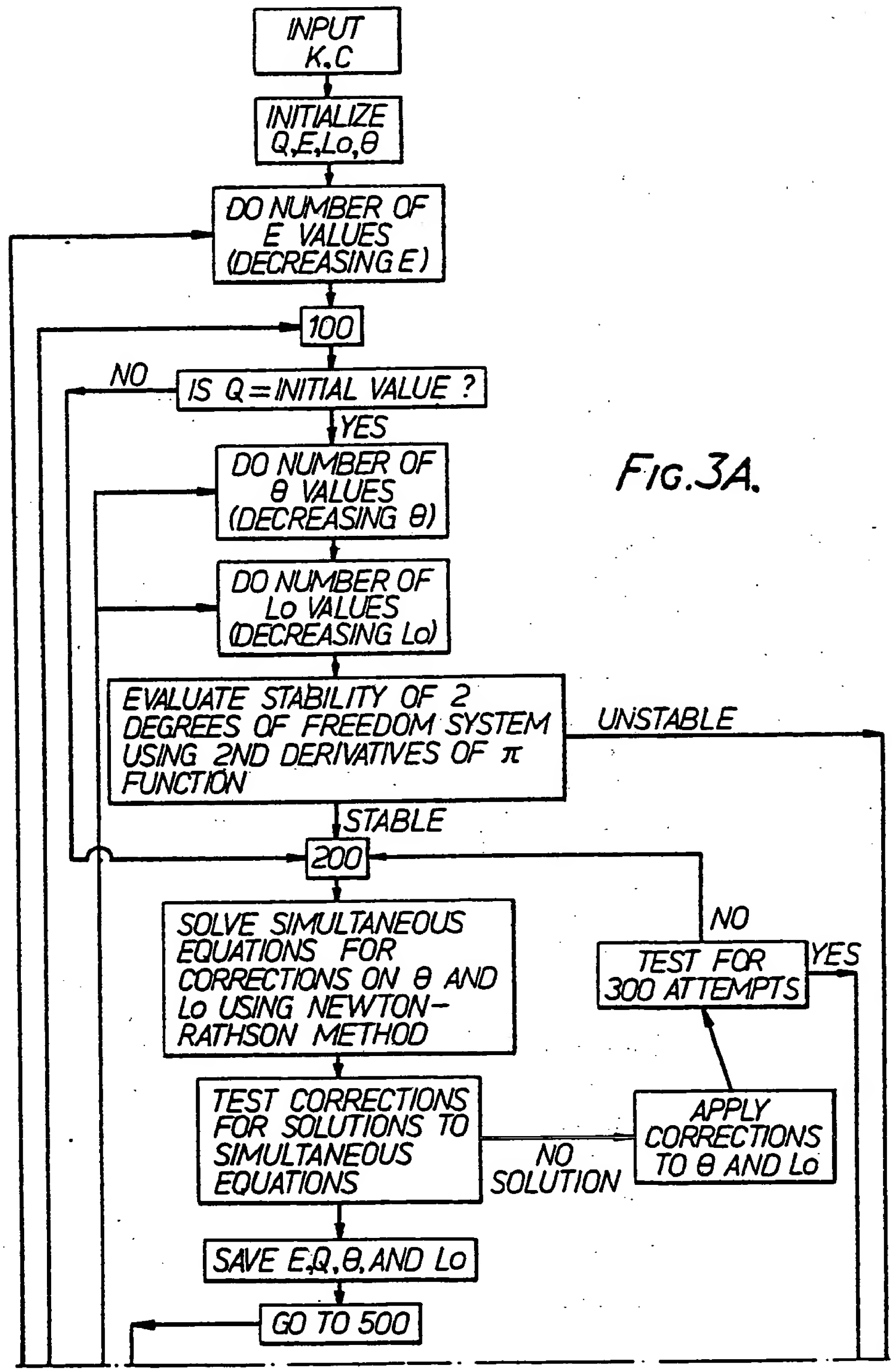
INPUT
K,C
INITIALIZE
Q,E,Lo,θ
DO NUMBER OF
E VALUES
(DECREASING E)
100
NO
IS Q=INITIAL VALUE ?
YES
DO NUMBER OF
θ VALUES
(DECREASING θ)
DO NUMBER OF
Lo VALUES
(DECREASING Lo)
EVALUATE STABILITY OF 2
DEGREES OF FREEDOM SYSTEM
USING 2ND DERIVATIVES OF π
FUNCTION
UNSTABLE
STABLE
200
SOLVE SIMULTANEOUS
EQUATIONS FOR
CORRECTIONS ON θ AND
Lo USING NEWTON-
RATHSON METHOD
NO
TEST FOR
300 ATTEMPTS
YES
TEST CORRECTIONS
FOR SOLUTIONS TO
SIMULTANEOUS
EQUATIONS
NO
SOLUTION
APPLY
CORRECTIONS
TO θ AND Lo
SAVE E,Q,θ,AND Lo
GO TO 500

FIG.3A.

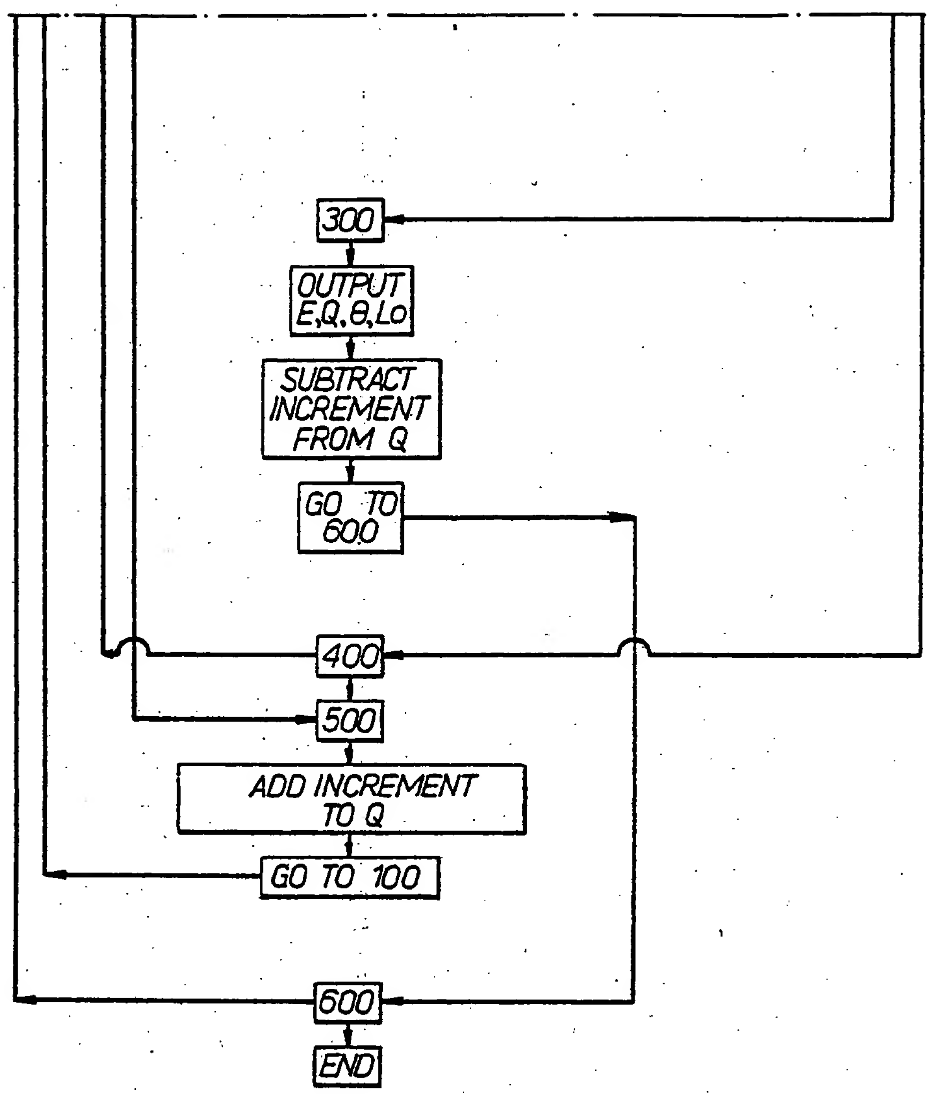
300
OUTPUT E,Q,θ,Lo
SUBTRACT INCREMENT FROM Q
GO TO 600
400
500
ADD INCREMENT TO Q
GO TO 100
600
END

FIG.3B.